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(54) **RF SHIELDED ENCLOSURE FOR
AUTOMATED TESTING**

FOREIGN PATENT DOCUMENTS

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U.S.C. 154(b) by 1048 days.

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(57) **ABSTRACT**

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An apparatus for restricting the flow of RF energy when
attached to a tester wherein test equipment is positioned
within the apparatus, comprising: a lid; a base; hinges for
attaching the lid to the base; EMI gasket material for sealing
seams; latches for attaching the lid to the base and for apply-
ing forces between the lid and the base to provide compres-
sion of the EMI gasket material for proper sealing of the
seams; a connection point for providing two axis alignment of
the base to the tester; and a positioning plate for providing
three axis alignment of the test equipment in relation to the
tester.

(51) **Int. Cl.**
H05K 9/00 (2006.01)

(52) **U.S. Cl.** **361/817**

(58) **Field of Classification Search** 361/817,
361/796, 816, 818

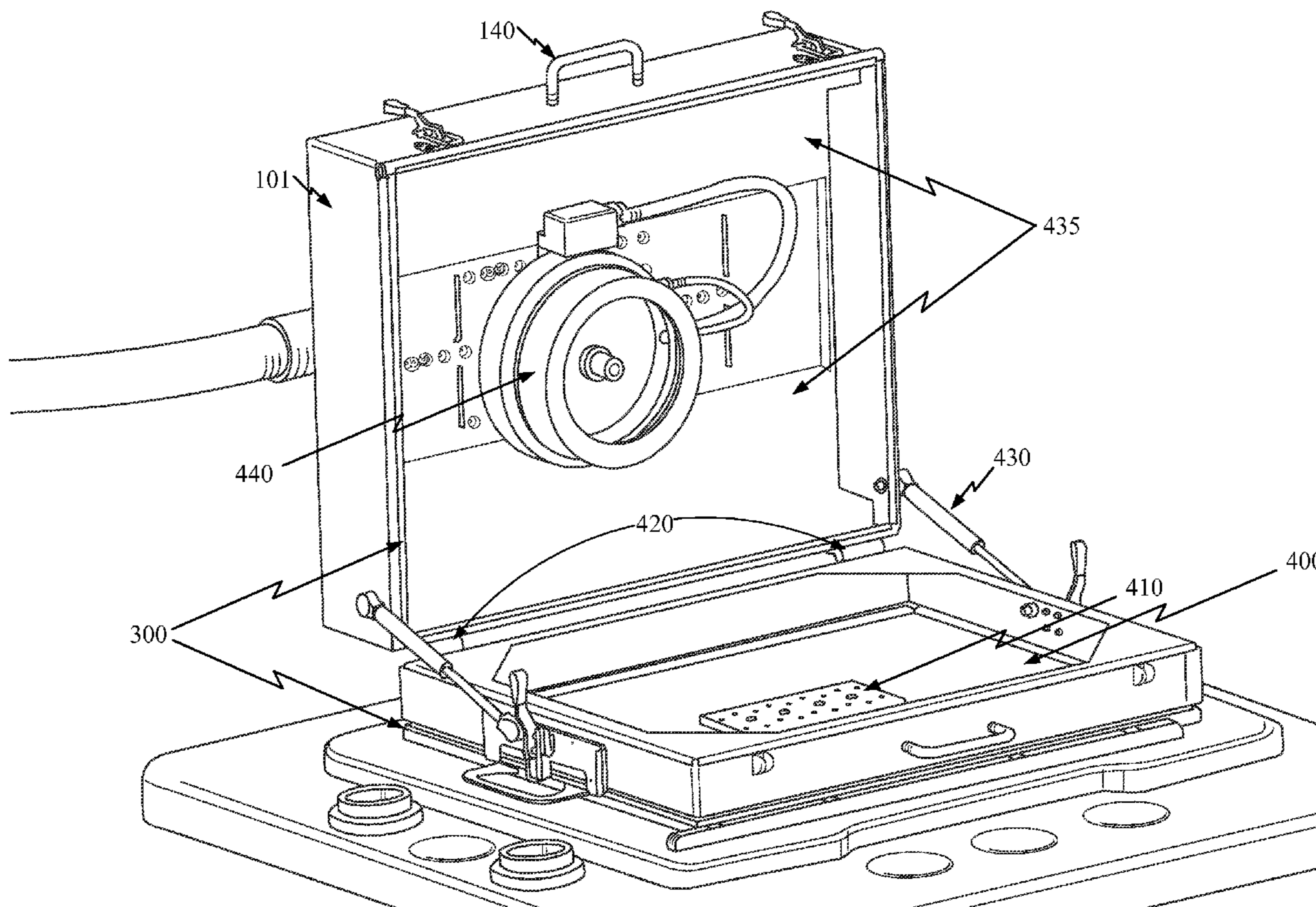
See application file for complete search history.

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10 Claims, 10 Drawing Sheets



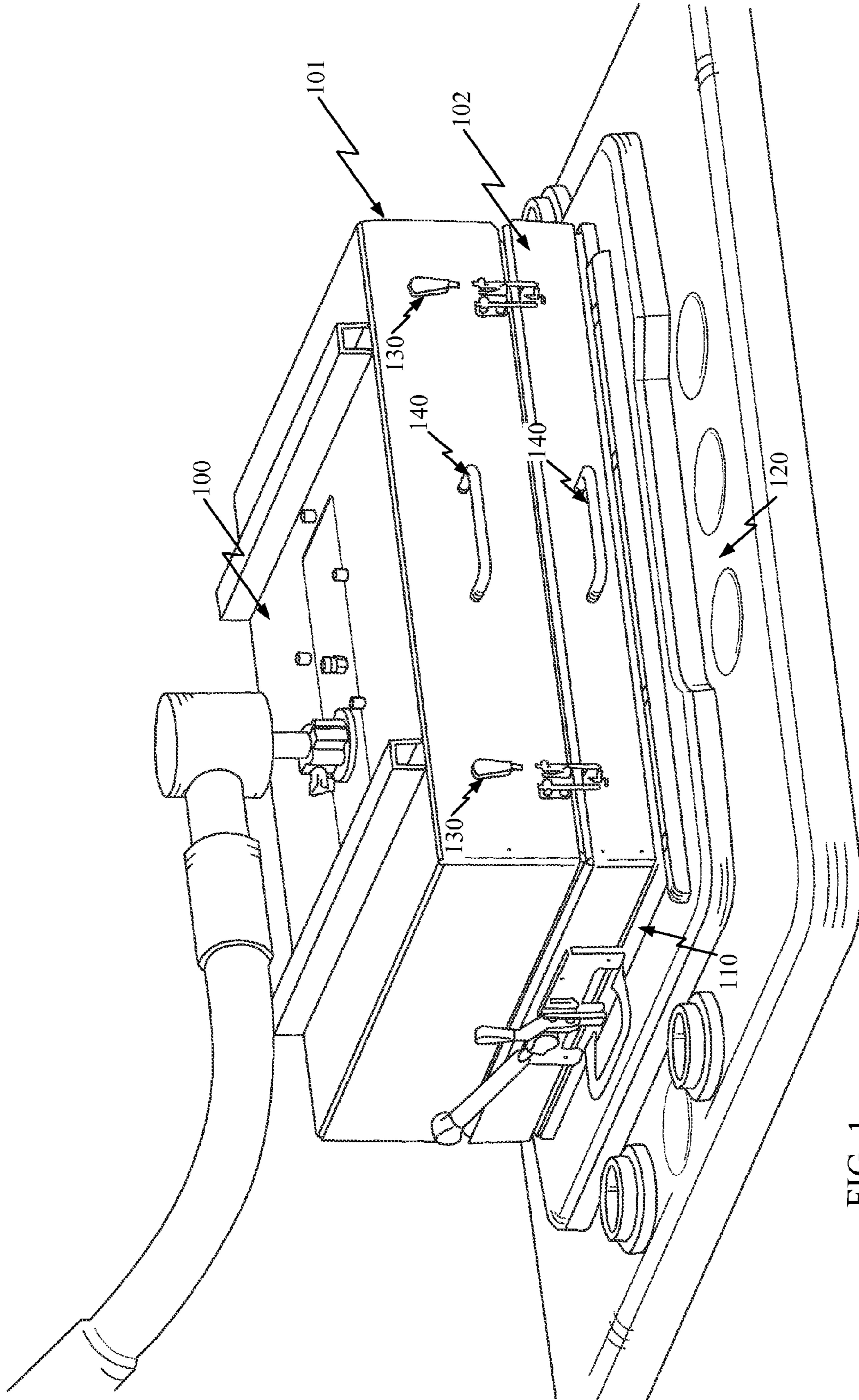
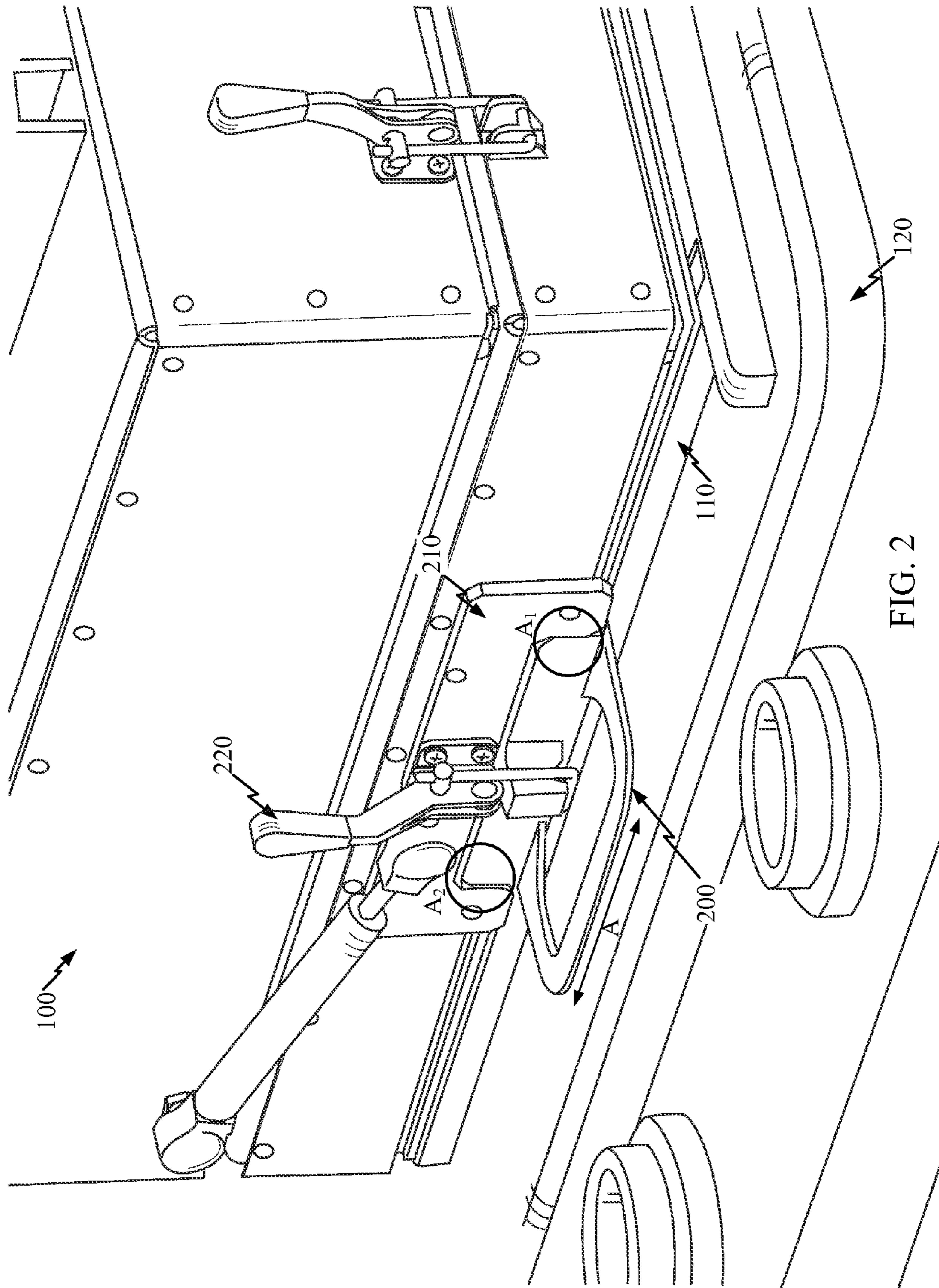


FIG. 1



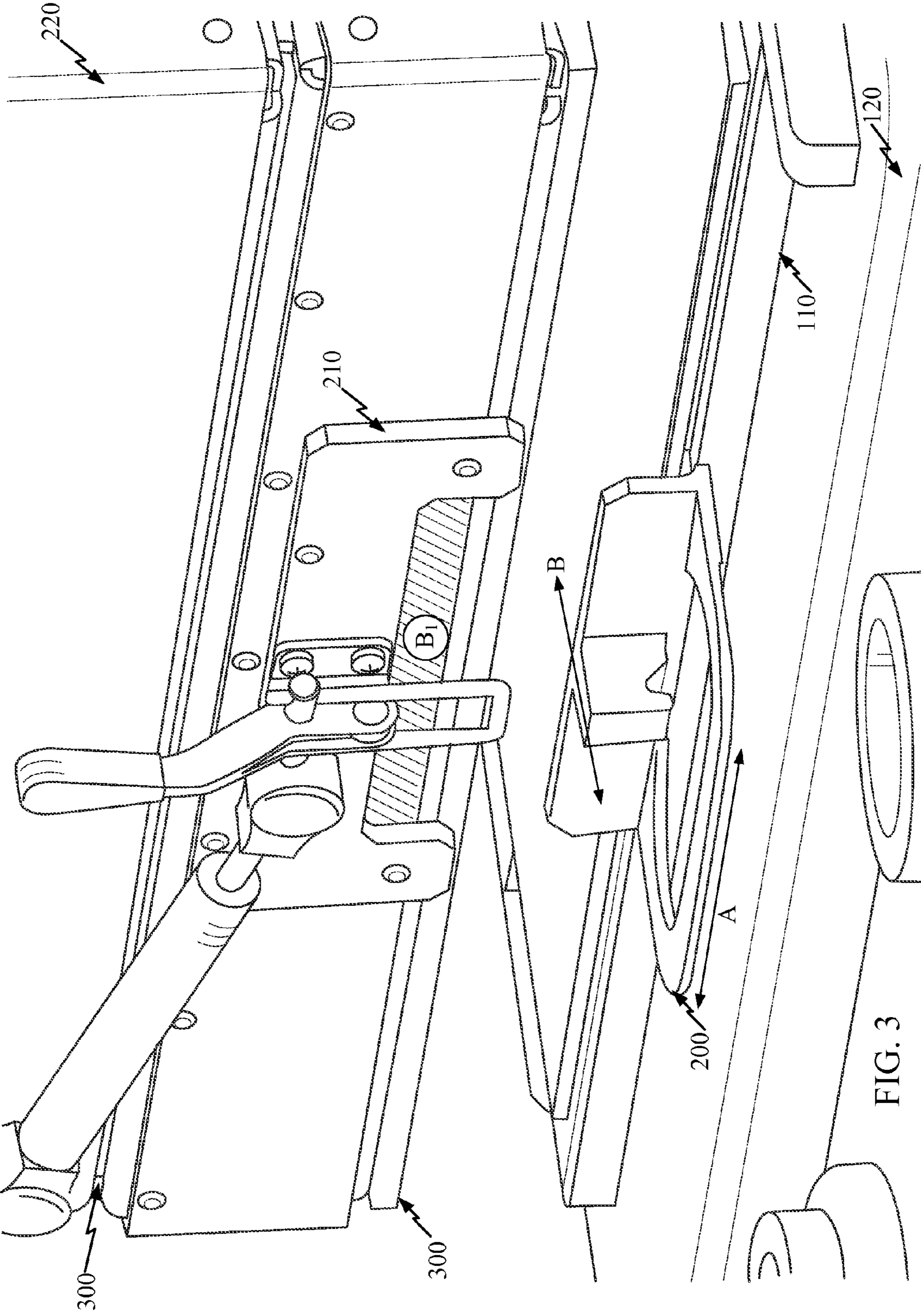


FIG. 3

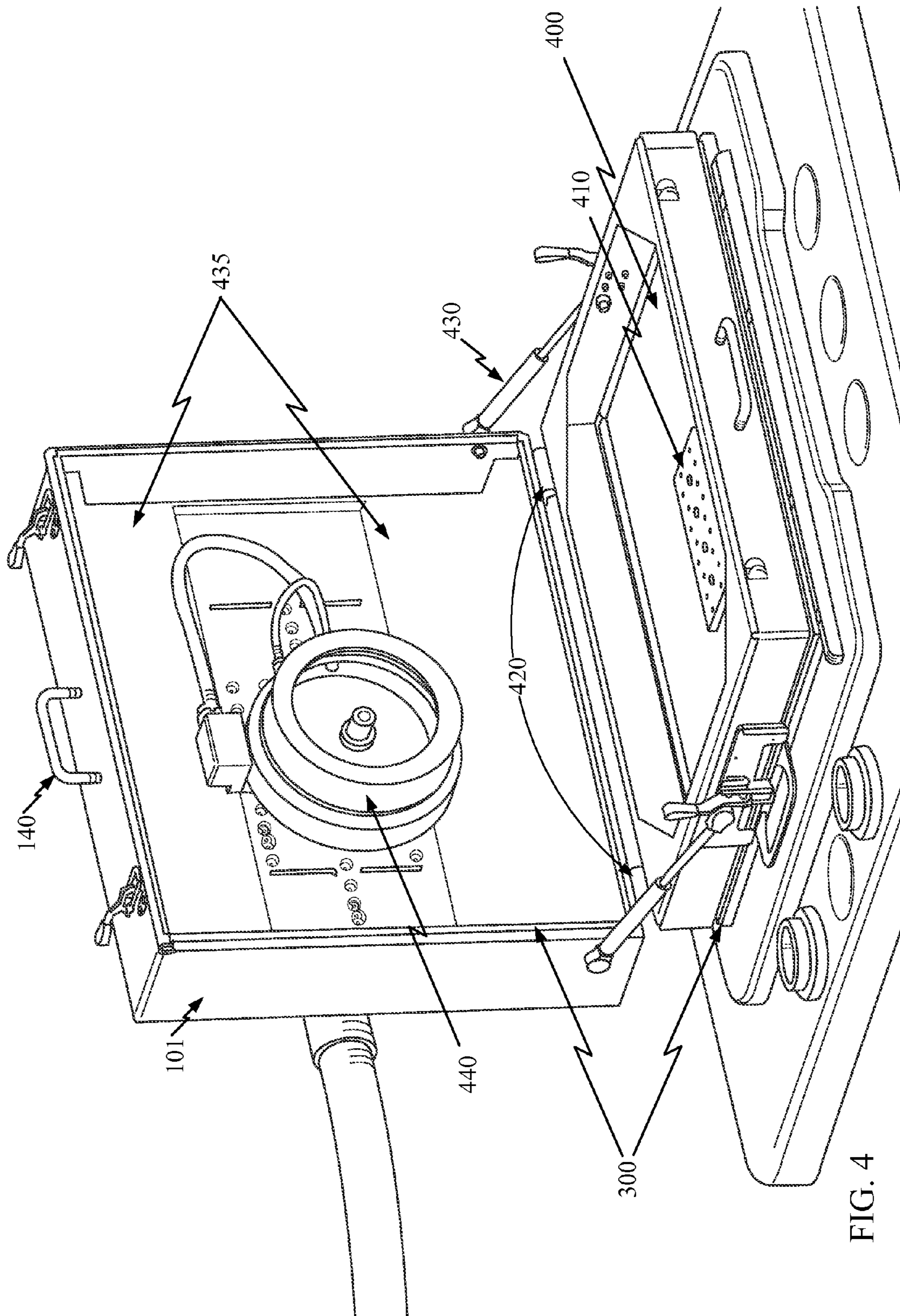


FIG. 4

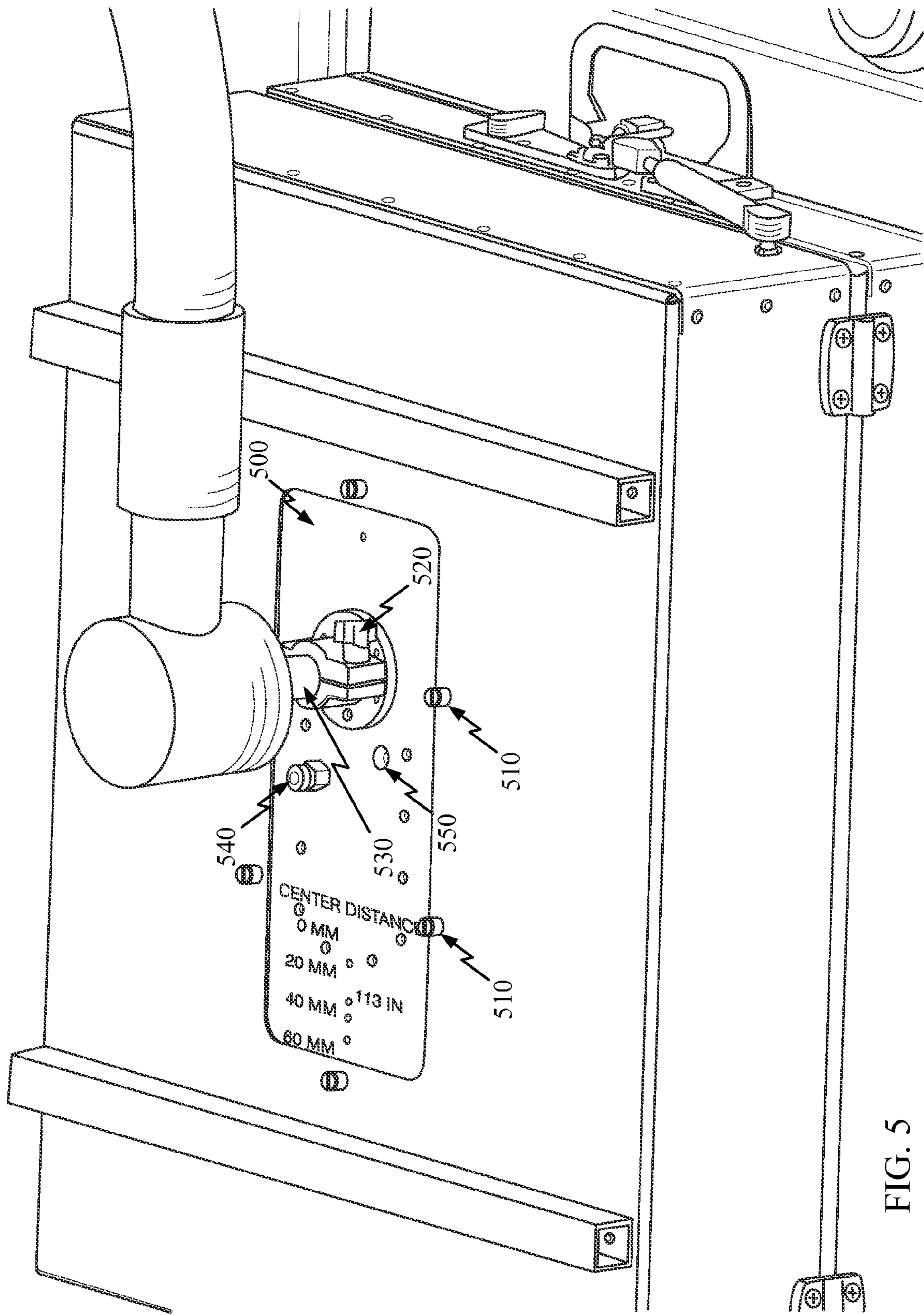


FIG. 5

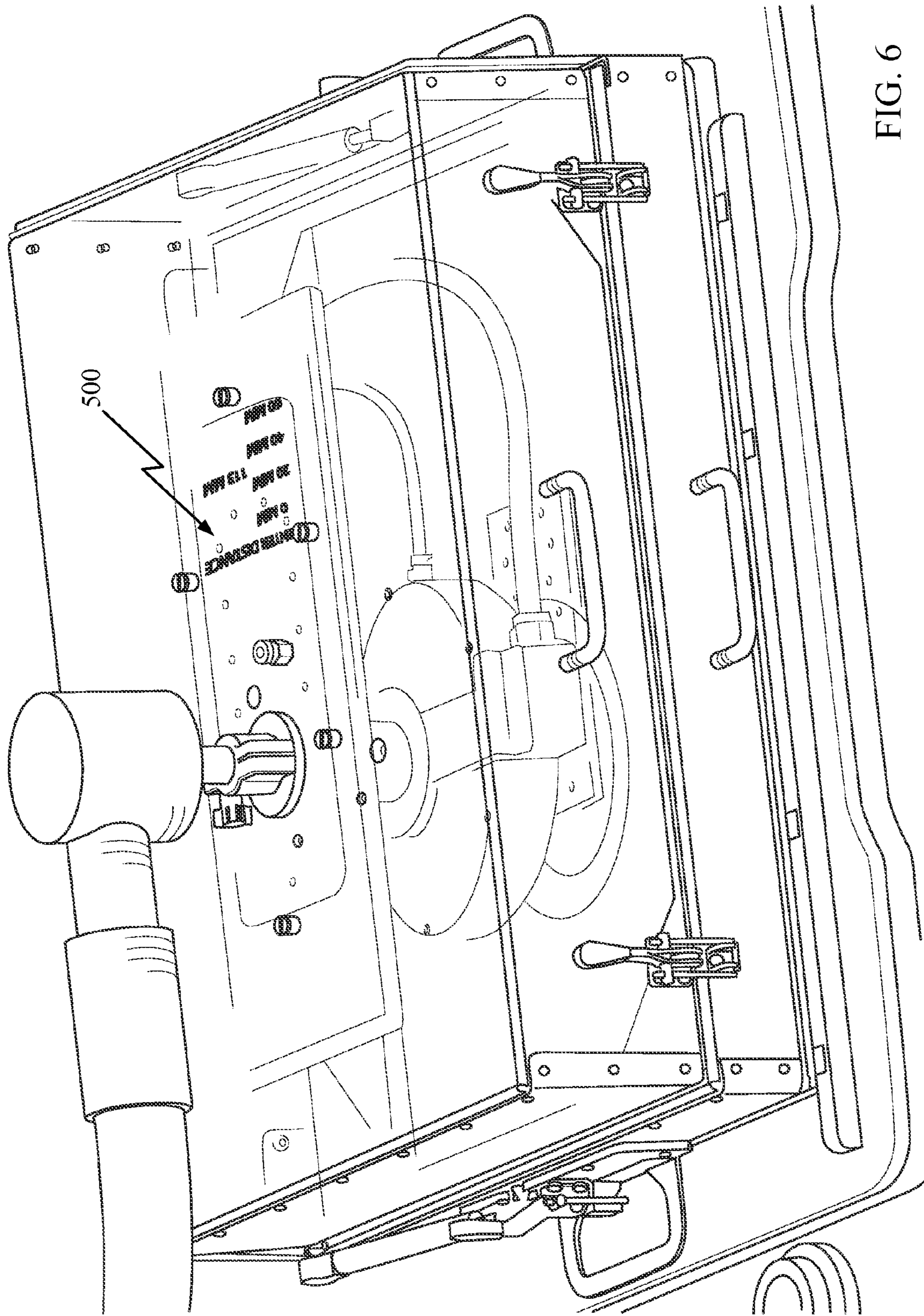


FIG. 6

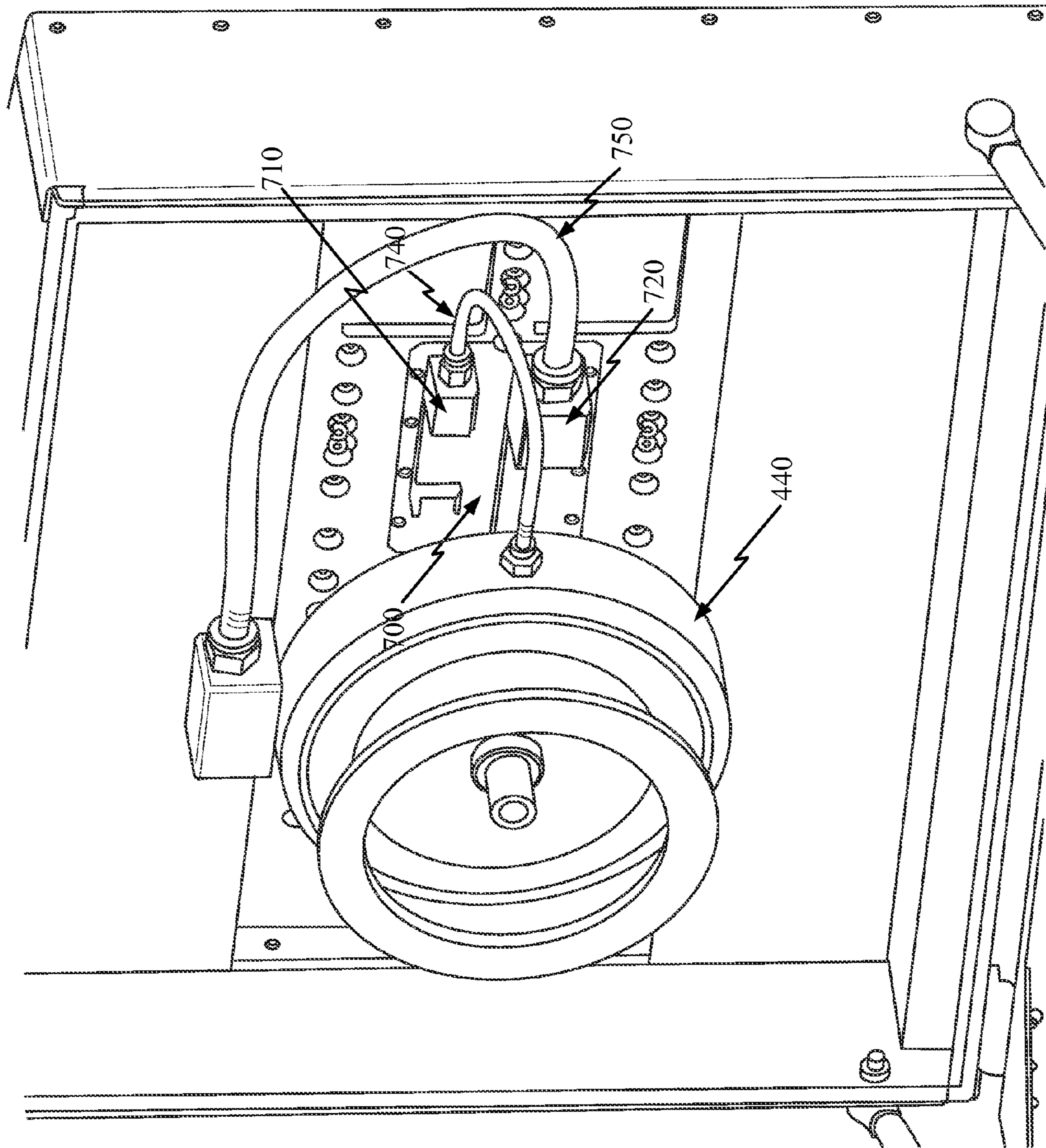


FIG. 7

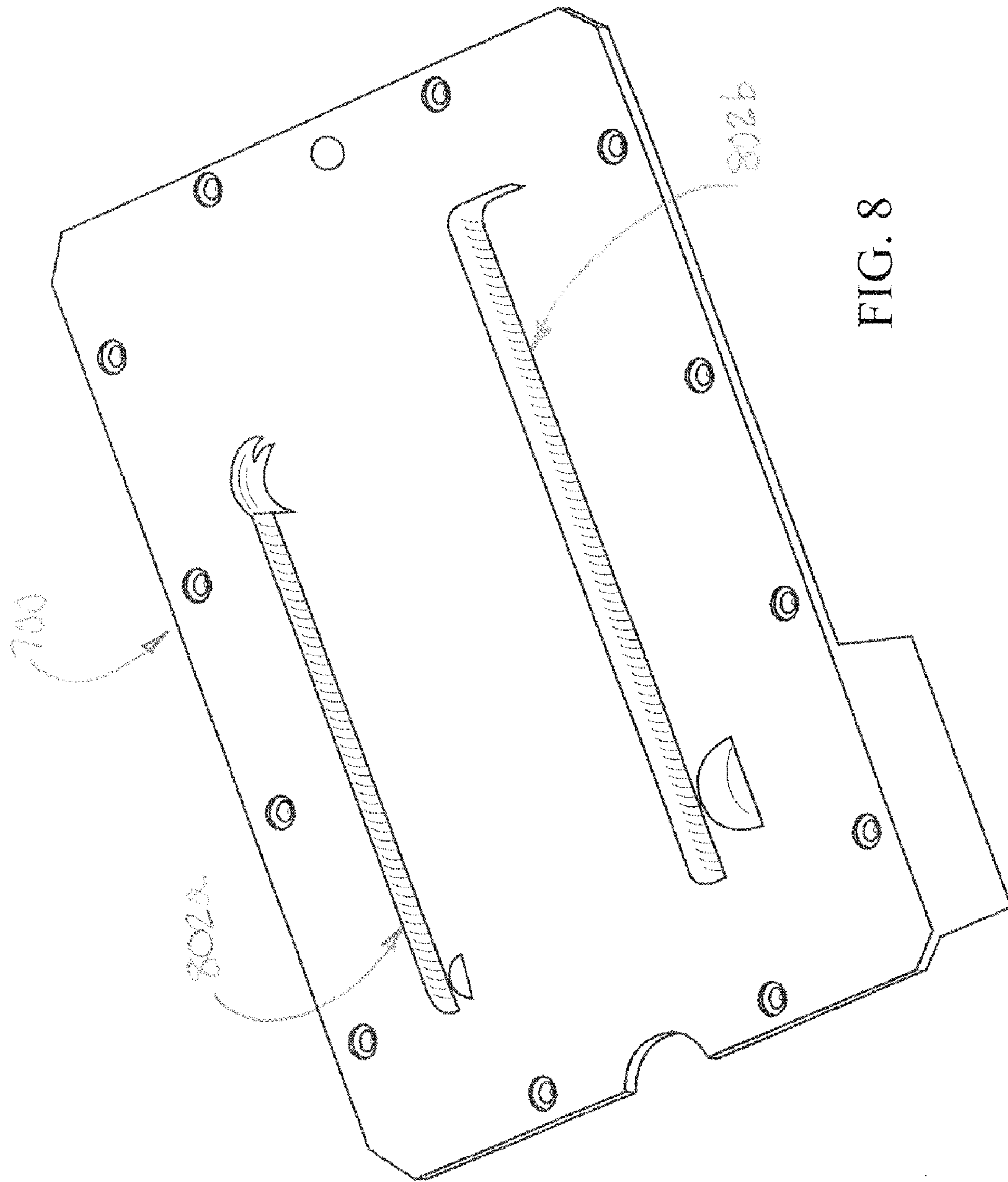


FIG. 8

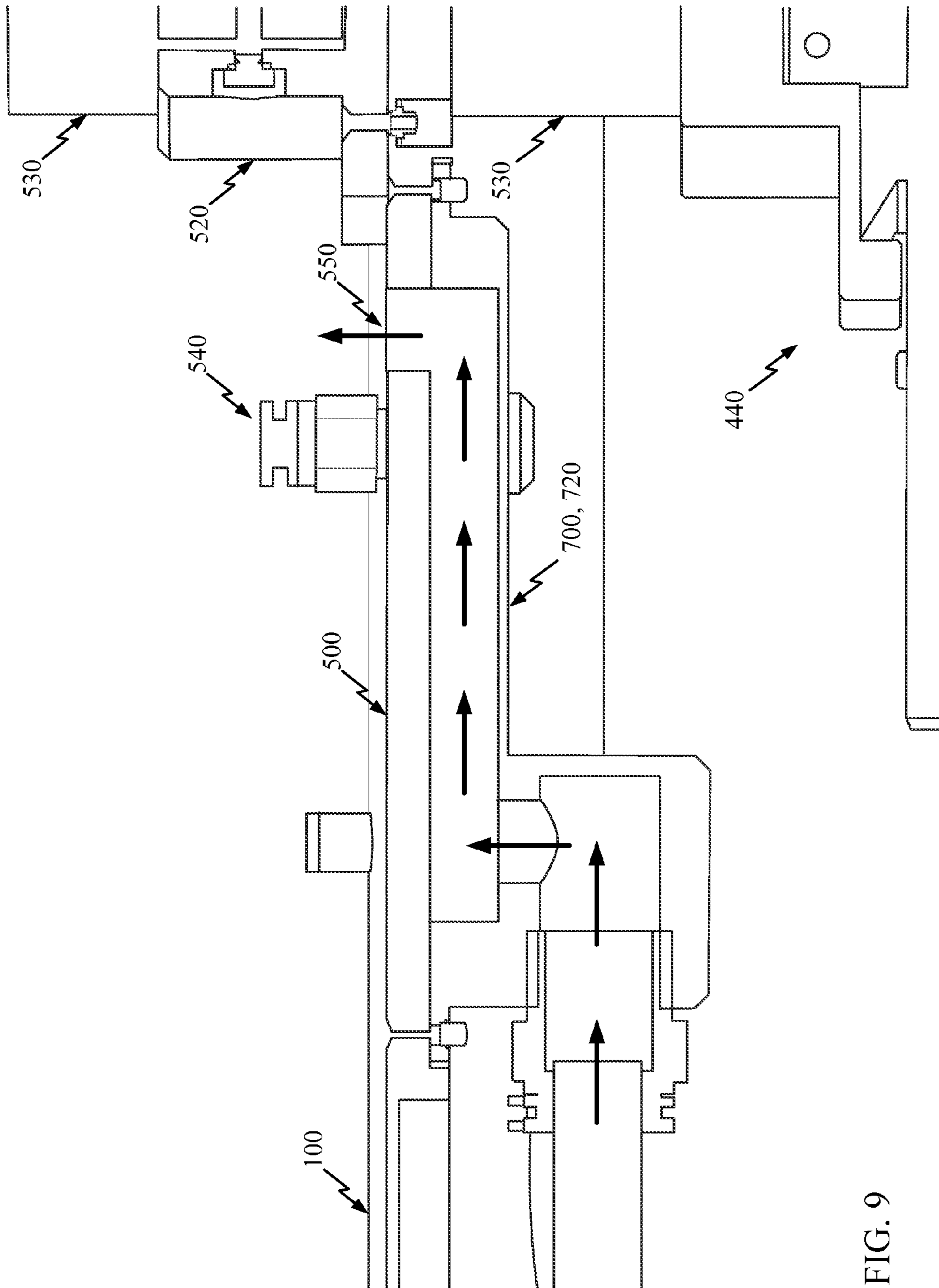


FIG. 9

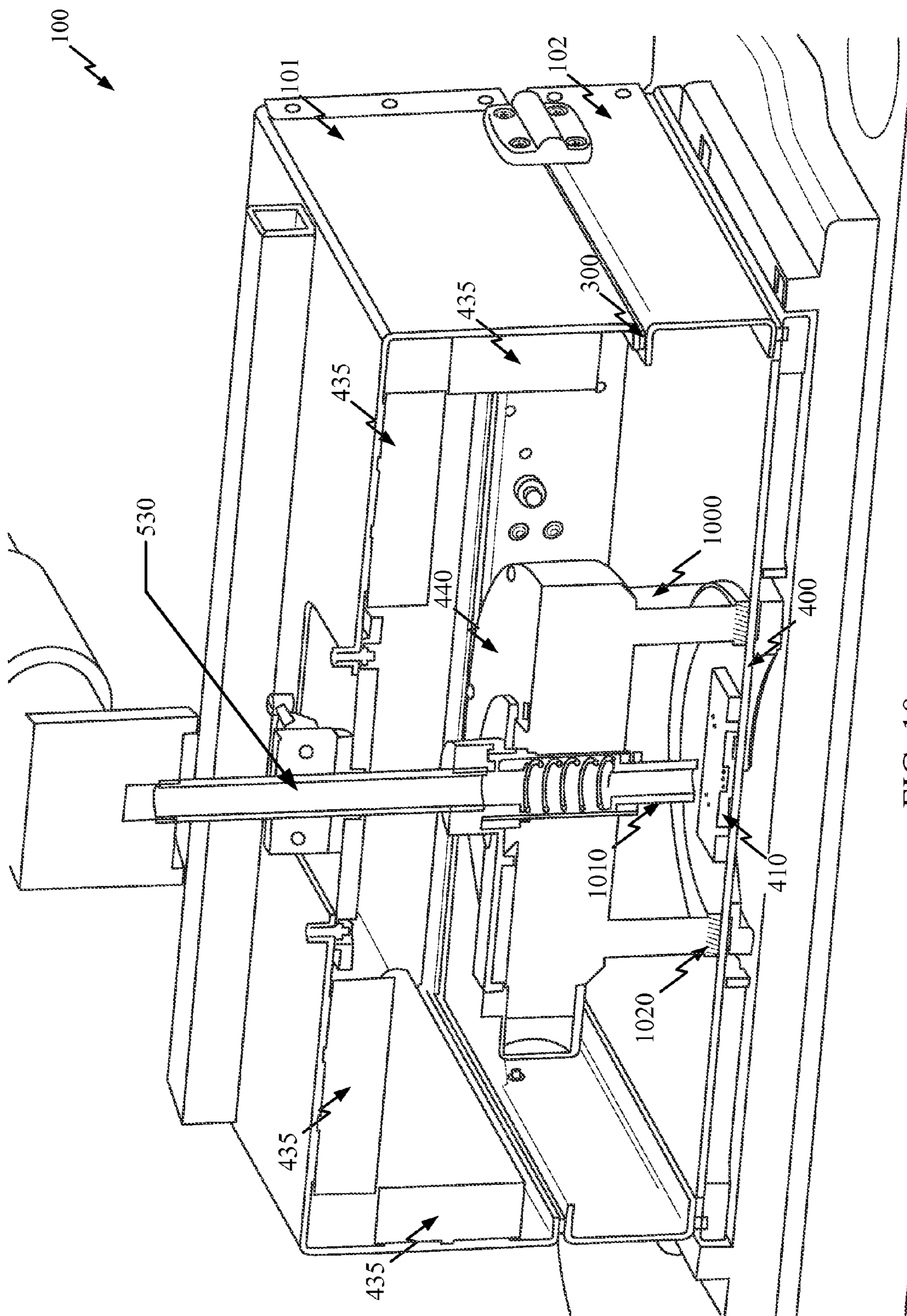


FIG. 10

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RF SHIELDED ENCLOSURE FOR AUTOMATED TESTING

FIELD

This disclosure relates to the shielding of electronic equipment from electromagnetic interference (EMI). More particularly, there is presented a RF shielded enclosure that attaches to testers and allows for the use of automated as well as non-automated test equipment.

BACKGROUND

The manufacture and subsequent testing of electronic components generates electromagnetic energy at least in the form of radio frequency RF. The RF energy generated, if not shielded, emanates throughout the manufacturing building potentially causing interference to any of the activities in the building. RF energy from outside the manufacturing facility may also penetrate into the building and cause interference.

One tool that is used to isolate a particular area within a RF rich environment is a screen room. These are large rooms covered entirely with costly RF shielding material such as copper mesh. They take a lot of time to build and consume valuable floor space. Over time the rooms deteriorate in their effectiveness and require costly and time consuming replacement.

Screen rooms house the test equipment. Items to be tested are brought into the screen room. Time is consumed in transporting the items under test. To reduce this time to transport, screen room location is restricted to being as close as possible to the point where the electronic components come off the manufacturing line.

This close proximity location further increases the cost of using screen rooms because not just valuable floor space is consumed but extremely valuable manufacturing floor space close to the production lines is consumed.

The invention is made with the above discussed problems in mind and aims to address the related problems.

SUMMARY OF THE INVENTION

An apparatus for restricting the flow of RF energy when attached to a tester wherein test equipment is positioned within the apparatus, comprising: a lid; a base; hinges for attaching the lid to the base; EMI gasket material for sealing seams; latches for attaching the lid to the base and for applying forces between the lid and the base to provide compression of the EMI gasket material for proper sealing of the seams; a connection point for providing two axis alignment of the base to the tester; and a positioning plate for providing three axis alignment of the test equipment in relation to the tester.

Additional features and benefits of the present invention will become apparent from the detailed description, figures and claims set forth below.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a drawing of the RF shielded enclosure attached to an industry standard tester;

FIG. 2 is a closer view of the attachment hardware used to attach RF shielded enclosure to the tester;

FIG. 3 is a partially exploded view of the attachment hardware for attaching RF shielded enclosure to a tester;

FIG. 4 is a drawing of the RF shielded enclosure when open;

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FIG. 5 is a drawing of detail of the lid of the RF shielded enclosure showing the environmental control positioning plate;

FIG. 6 is a drawing with the lid transparent showing the positioning plate's overall dimensions;

FIG. 7 is a drawing of the inside of the lid showing the RF cavity filter;

FIG. 8 is a drawing showing details of the RF cavity filter;

FIG. 9 is a cutaway drawing of exhaust air cavity filter;

FIG. 10 is a cutaway drawing of the environmental control chamber.

DETAILED DESCRIPTION OF AN EMBODIMENT OF THE INVENTION

The description and accompanying drawings are for purposes of illustration and are not to be used to construe the disclosure in a restrictive manner. In the following description, specific details are set forth in order to provide a thorough understanding of the invention. However, it will be apparent to one of skill in the art that the invention can be practiced without these special details.

Turning now to FIG. 1 of the accompanying drawings, there is shown RF shielded enclosure **100** attached to Test Board Frame **110** which is supported by Tester **120**. RF shielded enclosure comprises lid **101** and base **102**.

RF shielded enclosure **100** is constructed using metal for the basic shape. Metal naturally restricts or attenuates the passage of EMI energy or RF energy. Metal is durable, inexpensive and relatively easy to form. Those skilled in the art would understand that other materials could be used.

RF shielded enclosure **100** is small enough and constructed out of appropriate materials so that RF shielded enclosure **100** can be transported to the tester or to the items to be tested. Handles **140** are provided for efficient transport of the RF shielded enclosure **100** either alone or with equipment attached.

The RF shielded enclosure **100** can be designed to fit any test setup. Tester **120** and test board **110** and the environmental controller input **105** depict industry standard test equipment. This standard setup will be used for this disclosure. However, this should in no way be construed in anyway to limit the scope of the disclosure for RF shielded enclosure **100**.

The RF shielded enclosure **100** is shown in the closed position with environmental controller input **105** shown routed from an environmental controller (not shown) through the lid **101**. In this position, it is easily accessible during testing, stays solidly attached to the RF shielded enclosure **100** and swings out of the way when the RF shielded enclosure **100** is opened.

Latches **130** apply force to hold the lid **101** to the base **102** when closed. The force also helps to compress EMI gasket material (better illustrated in later figures) to provide proper RF shielding at the junctures. The term proper is used to describe implementation practices that achieve the goals set out for that portion of the design. The overall shielding affect is proper when the level of attenuation desired for the RF shielded enclosure **100** is achieved.

FIG. 2 shows in closer detail the attachment of RF shielded enclosure **100** to test board **110**. FIG. 2 represents only one side of the RF shielded enclosure **100**. It would be obvious to those skilled in the art that multiple connection points can be used. If the RF shielded enclosure **100** comprises multiple sides that are not in direct opposition to each other, or if it is irregular in shape or has curved edges, then multiple connec-

tion points may be used to adequately secure the RF shielded enclosure **100** to the test equipment.

In this embodiment two connection points are used, the one depicted by FIG. **2** and another positioned on the opposite side of RF shielded enclosure **100**. They are similar in design. Therefore the discussion depicted in FIG. **2** is readily transferable to the opposite side connection point. As will be shown the connection points are different in that they function as a pair. They apply aligning forces in opposing directions to bracket the RF shielded enclosure **100** into the proper position on test board **110**.

Frame handle **200** is attached to test board frame **110**. Alignment plate **210** is attached to RF shielded enclosure **100**. Latching clamp **220** is connected to alignment plate **210** and clamps to Frame handle **200**. Latching clamp **220** provides the connecting force needed to hold RF shielded enclosure **100** to test board frame **110**.

Frame handle **200** is designed to join with alignment plate **210** so as to provide two axis alignment of the RF shielded enclosure **100** to the test board frame **110**. Frame handle **200** is not part of the industry standard test equipment. Frame handle **200** may be a replacement to a preexisting handle; however, frame handle **200** is designed in concert with RF shielded enclosure **100**, alignment plate **210**, test board frame **110** and Tester **120**.

The region designated by A1 and A2 where frame handle **200** and alignment plate **210** make contact restricts movement between the test board frame **110** and RF shielded enclosure along the indicated A axis. This provides A axis alignment.

FIG. **3** shows RF shielded enclosure **100** lifted slightly from test board frame **110**.

The region designated B1 of RF shielded enclosure **100** makes contact with the inner surface of Frame handle **200**. Once RF shielded enclosure **100** is joined to test board frame **110** this contact surface between the two restricts motion along the B axis in one direction. The second connection point on the opposite side of RF shielded enclosure **100** similarly restricts motion. However this opposite connection point restricts motion along the B axis in the opposite direction of the connection represented in the FIGS. **2** and **3**. This provides B axis alignment.

Thus two axis alignment (A and B axis) is achieved. The accuracy of this alignment influences the operation of RF shielded enclosure **100** as will be further described.

It would be obvious to those skilled in the art that different designs may be used for achieving alignment and clamping, comprising: automated alignment tools and techniques, alignment pins, feedback mechanisms and robotic actuators.

Also in FIG. **3**, gasket material **300** can be seen attached to the underside of RF shielded enclosure **100**. The gasket material **300** used here in the contact seams and in other places in the RF shielded enclosure seal against EMI or RF leaks into or out of the RF shielded enclosure **100**.

FIG. **4** shows RF shielded enclosure **100** opened. When opened the RF shielded enclosure **100** provides access to the test interface board **400**. Test interface board **400** is supported by test board frame **110**. Positioned on the test interface board **400** are test sockets **410** where electronic hardware, comprising microprocessors are positioned for testing. RF shielded enclosure **100** covers, protects and shields the entire test interface board **400**.

Hinges **420** allow for opening of the RF shielded enclosure **100**. Gas springs **430** connected to the lid **101** and base **102** assist with the operation of the lid **101**. RF energy absorbing material **435** attached in various locations provides attenuation of EMI energy that is reflected within the RF shielded enclosure **100**. Industry standard environmental control

chamber **440** is shown. Not shown also is the use of metallic tape to seal corners, cracks and voids in the metal structure.

As already discussed, the use of handles **140** on RF shielded enclosure **100** provides efficient transportation capabilities. Here RF shielded Enclosure **100** may be transported with test interface board **400** attached.

FIGS. **5** and **6** show positioning plate **500**.

In FIG. **5**, positioning plate **500** is attached to RF shielded enclosure **100** and allows for positioning of environmental control chamber **440** which is inside the enclosure. Positioning plate **500** is of a larger dimension than the opening in RF shielded enclosure **100**. This oversize allows for varying the positions of positioning plate **500** along two axis without creating an unwanted gap between the plate **500** and RF shielded enclosure **100**. A gap would allow RF energy to disperse freely from or into RF shielded enclosure **100**.

Captive screws **510** hold positioning plate **500** in place once proper positioning is achieved. Those skilled in the art would understand that alternative attachment and alignment techniques may be used.

Marked onto the outside surface of positioning plate **500** where it is easily visible are indicators of the measured position of the positioning plate **500** and therefore the relative location of the environmental control chamber **440** in relation to the inside test structure.

There is shown clamp **520** through which environmental control chamber **440** is connected. The clamp **520** allows for vertical adjustment of the environmental control chamber **440** inside. Inside this clamp additional EMI restrictive material (not shown) is positioned around the interior of the hole through which the environmental control chamber **440** mounting shaft **530** passes. This seals the shaft **530** as to EMI energy yet still allows for the vertical movement of the mounting shaft **530** in relation to the RF shielded enclosure **100**.

Therefore three axis alignment of the environmental control chamber **440** inside of the RF shielded enclosure **100** is achieved. Those of skill in the art would understand that the axis of alignment could be practiced by other means comprising, movable slots, grooves or channels, low friction surface bearings, linear actuators and robotic manipulators.

The environmental control chamber **440** receives warm air through warm air input **540**. The warm air after being used is discharged into the RF shielded enclosure and allowed to escape. Conditioned air delivered to environmental control chamber **440** through shaft **530** is exhausted through air exhaust **550**.

FIG. **7** shows the under side of positioning plate **500** with filter **700**. Filter **700** contains warm air cavity filter **710** and exhaust air cavity filter **720**. Those skilled in the art would understand that the filters do not have to be co-located or that the number and types of total filters may be different or variable as the test setup requires.

Warm air delivered through warm air input **540** is delivered to the environmental control chamber **440** through warm air conduit **740**. Conditioned air that has been used exhausts from the environmental control chamber **440** through air exhaust conduit **750**.

FIG. **8** shows the cavities **802a** and **802b** of filter **700**. Many factors go into arriving at design dimensions for the cavity filter that restricts the passage of RF energy. Through trial and error or through careful calculations the relationship between length and the other dimensions of the cavity as well as the entry and exit holes define how well the cavity filter will work in the particular test set up and for particular frequencies.

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FIG. 9 shows the path for used conditioned air through the exhaust air cavity filter 720 and through positioning plate 500 as it exits the RF shielded enclosure 100.

FIG. 10 shows in a cutaway view more detail of the environmental control chamber 440 with the RF shielded enclosure 100 lid 101 closed. Environmental control chamber 440 encapsulates test sockets 410 by contacting the surface of test interface board 400 in a circular manner around test sockets 410. A seal 1020 of soft pliable material such as rubber is used to ensure an air resistant seal 1020 around test sockets 410. The pliable seal 1020 also is attached in such a way as to allow the warm air received through warm air input 540 and warm air conduit 740 to escape into the RF shielded enclosure 100 but not into the interior of the environmental control chamber 440 where devices are under test.

During testing conditioned air is brought to the device under test. For example a microprocessor is being tested. The conditioned air is directed onto the surface of the microprocessor by way of a spring loaded conditioned air nozzle 1010. By adjusting mounting shaft 530 the environmental control chamber 440 is brought down toward test interface board 400. The air nozzle 1010 makes contact with the microprocessor and the spring deflects as needed to allow environmental control 440 to be lowered further onto and seal with test interface board 400.

Conditioned air physical properties comprising temperature, humidity and pressure are cycled over time as required by the particular test scenario for the device being tested. This cycling of physical properties can result in the build up of condensation within the RF shielded enclosure 100. The warm air circulated through warm air chamber 1000 assists with reducing the build up of condensation.

Dry or hot air or gas injection systems can be integrated into a RF shielded enclosure 100 for automated testing applications. The added stream of heated air or dry gas reduces condensation and formation of ice when cold environmental conditions are simulated. The dry or heated air or gas can be applied directly to the device under test or within a shroud covering within the RF Shielded Enclosure.

A hot/cold plate can be integrated with RF shielded enclosure 100 to conductively cool or heat a device under test. The hot/cold plate could comprise Peltier, resistive, vapor phase change or circulating liquid/gas/air heating/cooling methods. The hot/cold plate can be part of the holding fixture for the device under test that clamps the device under test to its electrical contact socket on the test interface board.

Those skilled in the art would recognize that test equipment other than environmental control chamber 440 could be used with RF shielded enclosure 100. Because of the high degree of adjustment and flexibility in the RF shielded enclosure varying pieces of test equipment can be easily substituted for the environmental control chamber 440 discussed.

In the foregoing detailed description, the present invention has been described with reference to specific exemplary embodiments. It will be evident that various modifications and changes may be made without departing from the broader scope and spirit of the present invention. The specification and figures are accordingly to be regarded as illustrative rather than restrictive.

The invention claimed is:

1. An apparatus for restricting the flow of radio frequency (RF) energy when attached to a tester wherein test equipment is positioned within the apparatus, comprising:

- a lid;
- a base;
- hinges for attaching the lid to the base;

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electromagnetic interference (EMI) gasket material for sealing seams;

latches for attaching the lid to the base and for applying forces between the lid and the base to provide compression of the EMI gasket material for proper sealing of the seams;

an environmental control chamber;

a connection point for providing two axis alignment of the base to the tester; and

a positioning plate for providing three axis alignment of the environmental control chamber in relation to the tester.

2. The apparatus of claim 1 wherein the positioning plate further comprises:

passages for air, comprising conditioned air and warm air;

mounting location for RF filters;

clamp for holding a mounting shaft, the mounting shaft passes from exterior of lid to interior of lid through the clamp, the clamp comprises EMI shielding material; and markings on the surface for identifying location of the positioning plate in relation to the tester.

3. The apparatus of claim 1 wherein the connection point further comprises:

an alignment plate attached to the base;

a latching clamp for providing forces to securely connect the base to the tester and for compressing the EMI gasket material for proper sealing of the seams; and

a handle, the handle designed so that two axis alignment is achieved when used with the alignment plate mounted to the base.

4. The apparatus of claim 1 further comprising EMI absorbing material for absorbing reflected RF energy.

5. The apparatus of claim 1 further comprising RF cavity filters.

6. The apparatus of claim 1 further comprising conduits for providing connection paths between test equipment and RF cavity filters.

7. The apparatus of claim 1 further comprising handles for transport and manipulation of lid.

8. A method for restricting the flow of radio frequency (RF) energy when testing under a test plan wherein an apparatus is attached to a tester and test equipment is positioned within the apparatus, the method comprising:

attaching the apparatus to the tester, the apparatus comprising:

a lid;

a base;

hinges for attaching the lid to the base;

electromagnetic interference (EMI) gasket material for sealing seams;

an environmental control chamber;

latches for attaching the lid to the base and for applying forces between the lid and the base to provide compression of the EMI gasket material for proper sealing of the seams;

an environmental control chamber

a connection point for providing two axis alignment of the base to the tester; and

a positioning plate for providing three axis alignment of the environmental control chamber in relation to the tester; and,

operating the tester and test equipment according to the test plan.

9. An apparatus for restricting the flow of radio frequency (RF) energy when attached to a tester wherein test equipment is positioned within the apparatus, comprising:

a lid;

a base;

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means for attaching the lid to the base, wherein the lid may be opened;

electromagnetic (EMI) gasket material for sealing seams;

means for attaching the lid to the base wherein forces are applied between the lid and the base to provide compression of the EMI gasket material for proper sealing of the seams;

means for providing a connection point for providing two axis alignment of the base to the tester; and

means for providing a positioning plate for providing three axis alignment of the environmental control chamber in relation to the tester.

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15 **10.** A method for restricting the flow of radio frequency (RF) energy when testing under a test plan wherein an apparatus is attached to a tester and test equipment is positioned within the apparatus, the method comprising:

means for attaching the apparatus to the tester, the apparatus comprising:

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a lid;

a base;

hinges for attaching the lid to the base;

electromagnetic interference (EMI) gasket material for sealing seams;

latches for attaching the lid to the base and for applying forces between the lid and the base to provide compression of the EMI gasket material for proper sealing of the seams;

an environmental control chamber;

a connection point for providing two axis alignment of the base to the tester; and

a positioning plate for providing three axis alignment of the environmental control chamber in relation to the tester; and,

means for operating the tester and test equipment according to the test plan.

* * * * *